THE DEVELOPMENTAL RATES OF THYRIDOPTERYX EPHEMERAEFORMIS FROM FOUR LATITUDES AND NOTES ON ITS BIOLOGY (LEPIDOPTERA: PSYCHIDAE)[1]

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The principle range of the evergreen bagworm, *Thyridopteryx ephemeraeformis* (Haworth), extends in the North from New Jersey to eastern Nebraska and in the South from Georgia to Louisiana (Wollerman, 1965). There are scattered reports from west, north and south of this range. The eggs diapause during the winter, hatching around the first of June at Champaign, Illinois. The larvae develop slowly over the summer with the adults emerging during the last half of September. *Thyridopteryx ephemeraeformis* has but one generation each year throughout its range. Three of the most comprehensive studies on the bagworm are Jones (1927), Jones and Parks (1928) and Davis (1965).

We collected overwintering eggs of *T. ephemeraeformis* at four latitudes extending from the northern to the southern limits of its principal range: Chicago, Ill. at 42°N, Champaign, Ill. at 40°N, Atlanta, Georgia at 34°N and Savannah, Georgia at 32°N.

We reared the active stages under a 16 hour photophase at 29°C in battery jars 20 cm high and 15 cm in diameter. The lids were paper towels tightly fitted to the rearing chambers by first wetting and stretching them over the top. They were secured by rubber bands. These lids prevent small larvae from escaping and also allow air and moisture to diffuse in and out of the chamber. If the humidity in the rearing room did not exceed 50% the humidity in the chamber remained low enough to prevent the growth of a fungus which causes a

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high mortality among larvae. When the humidity went over 50%, it was necessary to clean the jars and provide new food whenever the fungus was seen.

Cut branches of *Juniperus virginiana* served as food. The ends of the cuttings and the tube of an automatic waterer were inserted into a 50 ml Erlenmeyer flask. Plastacene was packed around the stems and tube at the mouth of the flask to prevent the larvae from drowning. The automatic waterer was made from a baby food jar fitted with a #10 one hole rubber stopper. A 15 cm plastic tube was inserted into the stopper and pushed through until the end of the tube just protruded through the end of the stopper inside the jar. The other end of the tube extended to the bottom of the flask. Water flowed from the baby food jar as transpiration caused the level in the flask to drop. The water level was maintained at the bottom of the neck of the flask by cutting a hole in the tube at that level. The food remained fresh for at least ten days. When necessary the larvae were transferred to fresh cuttings by lightly gripping the posterior end of the bag with the fingers or forceps.

The larvae pass through six or seven instars. By observing the number of times a larva tied its bag to molt, Riley (1869, 1887) and Howard and Chittenden (1916) concluded that the bagworm has four instars. Apparently by the same method Jones and Parks (1928) estimated that there were four or more molts. From measurements of the width of head capsules dropped from bags containing newly molted larvae, Clegern (1966) determined that the bagworm " . . . revealed seven larval instars, with possibly only the female undergoing the full seven molts and the male undergoing six." Again by measuring head capsule width, Kaufmann (1968) concluded that bagworms pass through seven instars. Baerg (1928) measured the width of the head region of larvae which had just expanded the anterior end of the bag by adding new material and determined that the males go through seven instars and the females through eight. By measuring head capsules and fecal pellets which fell to the bottom of the rearing chamber and by noting the number of times larvae tied their bags, we found that determining the number of instars accurately was not possible. As the larvae age the time of molting becomes less synchronized with larvae of different instars being present in the rearing chamber. Because of this and the variability in head capsule size of individual larvae no distinguishable groups could be recognized. Only by rear-

TABLE I. Summary of Emergence Data on Four Populations of *Thyridopteryx ephemeraeformis.*

Location	Adult Emergence in Days		Number Emerged		CHI^2 of Pairs	
	Mean	Range	Male	Female	Indicated	
Chicago	89	75-102	5	14	0.56	
Champaign	91	80-101	4	9		98.15
Atlanta	119	101-150	39	26		
Savannah	118	98-151	—	20	0.86	

ing many individuals separately can the number of instars be accurately determined.

At the end of the last instar, the larvae again tie their bags to the substrate, but this time much more securely. After the bag is tied, the larvae add more silk to the inside and pupate in a head-down position. Ten days after the larvae had tied their bags to pupate, the bags were opened and sorted according to the sex of the pupae. Male pupae were easily identified by their smaller size, the greater amount of silk lining their bags, and the presence of legs and other appendages. Female pupae lacked wings, antennae and normally segmented legs.

Males and females emerge at approximately the same time but the males tie their bags for pupation about 1 1/2 weeks earlier than females. Males from Champaign spent from 24 to 37 days in the bag during this period while the females spent from 16 to 22 days. This is based on 20 males and 25 females.

When the males became adults, they emerged and flew. The females after molting remained inside the pupal skin, making it necessary to examine the inside of the bag every day to determine the time of the molt. This was signalled by the splitting of the anterior end of the pupal skin and the release of small tufts of yellowish hair which are conspicuous against the white silk which lines the bag.

Figure 1 shows that different populations do not emerge at the same time even though they are reared in the laboratory under identical conditions. The northern populations develop more rapidly than the southern populations.

Experiments began with those larvae which emerged from a bag during the first three days of the hatching period. The first day of this period was taken as the beginning of development for all larvae.

The similarities and differences of the northern and southern popu-

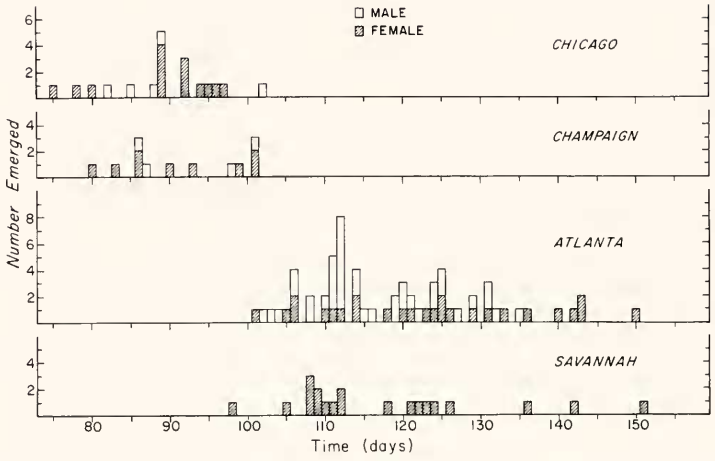

FIGURE 1. Frequency of emergence related to the number of days from larval eclosion to adult emergence of *Thyridopteryx ephemeraeformis* in rearings maintained at 29°C with a 16 hour photophase. Duration was measured from the first day of the three day period during which hatching occurred.

lations are apparent from Table 1. The first emergence of adults from the two southern populations occurred within three days of each other while the emergence of adults from the northern populations occurred within five days of each other. However, there are eighteen days between the latest first emergence of the northern populations and the earliest first emergence of the southern populations.

The span of time during which adults emerged after pupation was also quite different in the northern and southern populations. Chicago and Champaign populations took 27 and 21 days respectively to complete adult emergence while the Atlanta and Savannah populations required 49 and 53 days respectively. The arithmetic mean for the adult emergence occurred in the Chicago, Champaign, Atlanta and Savannah populations in 89, 91, 119 and 118 days respectively, again demonstrating the similarities within the northern and southern pairs and the differences between the northern and southern populations. The emergence periods of the northern and southern populations were

divided into thirds and on this basis 2 × 3 contingency tables were set up. A Chi^2 test showed that the Chicago and Champaign populations do not differ in the temporal distribution of emergence ($0.80 > P > 0.70$). Similarly, the Atlanta and Savannah populations do not differ ($0.70 > P > 0.60$).

Since the distribution of emergences within the northern pair and southern pair of populations were not significantly different, the data within each pair was combined. The total emergence period was divided into fifths and on this basis a 2 × 5 contingency table was set up. A Chi^2 test showed that the northern and southern populations do differ in their temporal distributions ($P < 0.001$).

The ratio of males to females in a population of bagworms varies considerably as observed in our field collections and laboratory rearings. However, it is difficult to explain why the Savannah population consisted entirely of females since males and females are present throughout the bagworm's range. This species of bagworm apparently is not parthenogenetic for we have found no case where unmated females have laid viable eggs. Mortality cannot be the only reason since the mortality rate from the 1st instar to adult emergence for this population was less than 17%.

The reason why *T. ephemeraeformis* develops at different rates at different latitudes is not immediately apparent. However, the differences are presumably of some adaptive value. The reason for this difference is the subject of a continuing study.

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ABSTRACT.—Laboratory rearings of *Thyridopteryx ephemeraeformis* from eggs which were collected at four latitudes over its range showed that northern populations completed their development sooner than did southern populations under controlled conditions of temperature and photoperiod. The bagworm takes approximately seven instars to complete its development. During pupation the males spend 2 to 15 days longer in the bag than do the females. An efficient rearing technique results in low mortality.—R. D. MORDEN and G. P. WALDBAUER, *Department of Entomology, University of Illinois, Urbana, IL 61801.*

Descriptors: Lepidoptera; Psychidae; *Thyridopteryx ephemeraeformis.* developmental rates; Chicago, evergreen bagworm; Champaign, evergreen bagworm; Atlanta, evergreen bagworm; Savannah, evergreen bagworm, evergreen bagworm.